PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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BEARPAW LAKE DAM
HILL COUNTY, MONTANA
MT - 115

PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

MONTANA DEPARTMENT OF FISH, WILDLIFE, AND PARKS
(OWNER - OPERATOR)

PREPARED BY:

Christian, Spring, Sielbach & Associates
Bozeman, Montana

Assisted by:
Northern Testing Labs, Inc.
Great Falls, Montana
March, 1980

Seattle District
United States
Army Corps of Engineers

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Personnel of Christian, Spring, Sielbach & Associates, principal contractor, and Northern Testing Laboratories, Inc., subcontractor, under a contract with the Montana Department of Natural Resources and Conservation (MDNRC) and with representation from the Montana Department of Fish, Wildlife, and Parks, the MDNRC, and the U.S.D.A., Soil Conservation Service, inspected Bearpaw Lake Dam on 19 and 20 June, 1979 under the authority of Public Law 92-367. The project is located in Section 29 Township 30 North, Range 16 East, M.P.M., on Beaver Creek within the boundaries of Beaver Creek Park, Hill County, Montana, about 20 miles south of the City of Havre.

This report was compiled from information obtained during the onsite inspection, review of construction plans and development and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

Findings and Evaluations

Bearpaw Lake Dam was originally constructed in 1958 by the Montana State Fish and Game Commission (now Montana Department of Fish, Wildlife, and Parks). The dam is in Beaver Creek Park, which is owned and operated by Hill County. Bearpaw Lake is used primarily for recreational fishing. Campsites are located near the lake. Lake levels are maintained by an uncontrolled overflow chute spillway. A gated outlet works is available to release flows downstream as needed. However, since Beaver Creek Reservoir has been constructed downstream as a multi-purpose flood control, irrigation and recreation project, outlet control gates are used infrequently at Bearpaw Lake.

Bearpaw Lake has a surface area of 36 acres at spillway crest elevation, and 535 acre-feet of permanent storage at spillway crest. The 59 foot high dam impounds approximately 905 acre-feet of water at dam crest elevation 3606.0 feet MSL. The drainage area is 49 square miles. On the basis of criteria in the U.S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. Beaver Creek Reservoir is located about 7 miles downstream from Bearpaw Lake. There are no inhabitable structures near Beaver Creek between the two dams. Failure of Bearpaw Lake Dam would damage the road and bridges downstream in the distance between the two dams. It could endanger the lives of overnight campers, fishermen, and recreationists using the area downstream from Bearpaw Lake. Dam failure would increase discharge from Beaver Creek Reservoir. However, under normal conditions Beaver Creek Reservoir has sufficient flood and surcharge storage available to contain the 900+ acre-feet that would be released by a sudden failure of Bearpaw Lake Dam. The conclusions on probable damage are based on the field visit and engineering judgment. No dam breach analysis or routing of a dam breach hydrograph was made for the downstream area.

The project is classified as having a significant (Category 2) downstream hazard potential. Inspection criteria (Ref. 1) recommend that an intermediate sized project with a significant downstream hazard potential rating be capable of handling from 1/2 to the full probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Because there are no permanently inhabited residences immediately below the dam, we recommend one-half of the detailed PMF be adopted as the spillway design flood (SDF).

The estimated PMF for the 49 square mile drainage basin resulted from a general storm PMP developed for this dam safety study. The PMF has an estimated volume of 50,500 acre-feet and a peak flow of 96,800 c.f.s. The spillway has a discharge capacity of approximately 3980 c.f.s. with the reservoir at top of dam, elevation 3606.0 feet MSL. The routing of the PMF was started with the reservoir at spillway crest, elevation 3598.0 feet MSL. Routing of the full PMF developed for Bearpaw Lake Dam indicates that the dam is overtopped when only 9 percent of the total PMF flood volume enters the reservoir. Routings of lesser hypothetical floods made by applying percentages to the PMF ordinates, showed that a flood corresponding to 5 percent PMF ordinates is just controlled by the project. The dam is constructed of materials that would erode and fail when overtopped by flood waters.

The visual inspection revealed no signs of cracking, bulging, unusual settlement, or damaging seepage that would indicate distress. A minor slump upstream of the left abutment is localized and appears to be founded on natural ground (glacial till and bedrock). Riprap on the upstream face of the embankment and the left abutment has deteriorated, apparently from exposure, and has slumped into the reservoir at several locations exposing the embankment. Erosion is taking place on both sides of the chute spillway adjacent to the sidewalls and running the full length of the chute on the downstream slope.

On the basis of the field inspection, development and study of hydrologic data, Bearpaw Lake Dam does not now conform to Corps guidelines with respect to discharge and/or storage capacities to safely handle the recommended spillway design flood (SDF).

Stability of the dam cannot be fully evaluated because information on performance at maximum loading and strength and permeability characteristics of the embankment materials are unavailable.

Recommendations

A downstream warning plan, for use in the event of impending dam failure, needs to be developed and placed in action. Coordinate the warning plan with the plan developed for Beaver Creek Reservoir Dam and the downstream area. Inspect the entire length of the monolithic concrete outlet conduit and repair as required. Repair the slump on the upstream left abutment. Upgrade and/or replace riprap rock on entire upstream face of embankment above and below spillway crest elevation. Repair eroded areas adjacent to the chute spillway on the downstream slope. Remove trees and root systems on the downstream slope; backfill disturbed

areas, compact and revegetate with grasses. Maintain the dam crest roadway at design elevation or at bridge deck elevation over entire crest length.

Conduct engineering studies taking into account upstream and downstream projects to better determine the downstream hazard and spillway design flood (SDF) for Bearpaw Lake Dam. Modify the project as studies indicate.

Conduct and place on file, stability analysis of the dam embankment. Studies should include assessment of insitu strength properties of the embankment, foundation and abutment materials, and determination of phreatic surface conditions by installing and monitoring piezometers. We recommend that stability, seepage, and seismic response analysis be performed by a qualified geotechnical engineer.

Develop and implement an operations and maintenance plan for the project which involves periodic inspections by dam operations and maintenance personnel. Conduct inspections of Bearpaw Lake dam at least every 5 years by qualified engineers experienced in earth dam design and construction.

Prior to performing engineering studies and remedial construction that may be required, coordinate the work with the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

Bob B. Gemmell
Professional Engineer
Montana 504 E.

PERTINENT DATA

1. General

Federal I.D. Number	MT-115
Owner	Montana Department of Fish, Wildlife and Parks
Operator	Montana Department of Fish, Wildlife and Parks
Date Constructed	1958
Purpose	Recreation
Location	Shambo Quadrangle, Section 28, T.30N., R.16E., M.P.M., Hill County, Montana
Watershed	Beaver Creek, Tributary to Milk River
Size Classification	Intermediate
Downstream Hazard Potential	Category 2 (significant)

2. Reservoir

Surface Area at Normal Pool (Spillway Crest Elevation 3598.0 feet MSL)	36 acres
Storage at Normal Pool (Spillway Crest)	535 A.F.
Surcharge Storage (Spillway Crest to Top Dam)	370 A.F.
Storage at Dam Crest	905 A.F.
Drainage Area	49 square miles
Surface water elevation on 19 June, '79.	3598.5 feet M.S.L.

3. Spillway

Type	Uncontrolled, two bay Reinforced Concrete Chute
Crest Elevation	3,598 feet M.S.L.

3. Spillway
Continued

Length of Crest	47 feet (effective)
Spillway Capacity (Elevation 3606.0 feet MSL, Top of Dam)	3,980 c.f.s.

4. Outlet Structure

Conduit (reinforced concrete monolith-horseshoe shape)	3 feet wide x 3 feet high at apex
Conduit Length	320 feet
Gate Well Houses 2 slide gates in wet wells with center wall partition	
Slide Gates	2 - 36-inch diameter
Capacity (W.S. at Spillway Crest)	160 c.f.s.

5. Dam

Type	Zoned Earth Embankment
Hydraulic Height (Crest to Toe)	59 feet
Top of Dam	3606.0 MSL
Crest Length	380 feet
Crest Width	18 - 20 feet
Upstream Slope	1V on 3H to 1V on 4H
Downstream Slope	1V on 2H

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Bearpaw Lake Dam, owned by the Montana Department of Fish, Wildlife and Parks.

The National Dam Inspection Act, Public Law 92-367 dated 8 August, 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May, 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phased study procedure for investigation and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam.
(2) based upon an evaluation of the available data and a visual inspection.
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted.
(4) not intended to include extensive explorations, analysis or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspection, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work.

Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner(s) and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and action or failure to act under this act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify current conditions of the dam and appurtenances and to determine if emergency measures and/or additional studies, investigations and analyses are needed, so that corrections can be made in a timely manner by non-federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on a review of 'as-built' plans, visual inspection of the project, and a review of operational and hydrological data. No design or construction records were available for review and analysis, other than construction plans. Inspection procedures and criteria were those established by the Recommended Guidelines for the Safety Inspection of Dams (Ref. 1) and as supplemented in the Contract for Professional Personal Services for Dam Safety Investigation Pursuant to Public Law 92-367, National Dam Safety Program.

The inspection was conducted jointly by personnel from Christian, Spring, Sielbach & Associates and Northern Testing Laboratories, Inc., subcontractors. Personnel who participated in the field inspection and contributed to this report were:

CSSA

Bob B. Gemmell, Engineer, Team Leader
Kent D. Brewer, Structural Engineer
Alfred Cunningham, Hydraulics/Hydrology (report only)

N.T.L.

Robert Gillespie, Geotechnical Engineer
Bill Henning, Geologist

Other personnel present and participating in the inspection included:

Glenn McDonald, Montana Department Natural Resources & Conservation
Larry Tegg, Montana Department Natural Resources & Conservation
Joe Calder, United States Soil Conservation Service
Richard Misplon, Montana Department Fish, Wildlife, and Parks

This report has been reviewed by: The Montana Department of Fish, Wildlife and Parks; Montana Department of Natural Resources and Conservation, and Hill County Commissioners; and their written comments are enclosed in Appendix A.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

a. Location and Owner

Bearpaw Lake Dam is located on Beaver Creek within Beaver Creek Park in Section 28, Township 30 North, Range 16 East, M.P.M., Hill County, Montana, approximately 20 road miles south of Havre, Montana. The dam is owned and operated by the Montana Department of Fish, Wildlife and Parks (new name) as a public recreational area and fisheries. Beaver Creek Park is owned and operated by Hill County. Beaver Creek flows north to enter the Milk River at a point approximately 2-1/2 miles north of Havre, Montana. Beaver Creek Reservoir is located on the drainage approximately 7 miles downstream from Bearpaw Lake, and East Fork Dam is located approximately 10 miles upstream on the Rocky Boys Indian Reservation. (see Plates 1 and 2)

b. Description of Dam and Appurtenances

Bearpaw Lake Dam is a zoned earthfill structure with a height of 59 feet and a crest length of 380 feet. It has a two-bay uncontrolled reinforced concrete chute spillway with an ogee shaped crest. A center pier and the spillway side walls support a bridge for the road on the dam crest. (Photos 4, 5, & 6) The effective crest length of the 'ogee' section is 47 feet. The dam impounds approximately 535 acre-feet at spillway crest elevation 3598.0 feet M.S.L. and approximately 905 acre-feet at dam crest elevation 3606.0 feet M.S.L.

The low level outlet is a horseshoe shaped monolithic concrete conduit located near the center of the dam. (Plate 3) It is controlled by two slide gates in tandem located near the dam axis at the bottom of a reinforced concrete gate tower with hand operated hoist lifts located in a gate house at the top of the gate well. (Photo 12)

c. Hazard Potential

Based on visual reconnaissance and engineering judgment, Bearpaw Lake Dam is located such that a sudden breach would damage bridges and the highway downstream. It would raise the reservoir levels in Beaver Creek Reservoir Dam which is located approximately 7 miles downstream, and could endanger the lives of campers, recreationists, and fishermen who utilize the area, particularly during the summer months. There are no permanent residences between the two reservoirs. On the basis of this information and in accordance with the recommended inspection guidelines Bearpaw Lake Dam project size is intermediate and the downstream hazard potential is significant. (Category 2)

The potential hazard to Beaver Creek Reservoir Dam that would be attributed to overtopping and failure of Bearpaw Lake Dam during the routing of the PMF or a lesser flood event is undetermined. It has been determined that Beaver Creek Reservoir Dam overtops when routing a hypothetical flood event less than the PMF without consideration of breach failure of Bearpaw Lake Dam. (Ref. 9)

1.2.2 Regional Geology - Bearpaw Lake Dam

The Bearpaw Mountains region contains a wide range of intrusive and extrusive mafic, subsilicic-alkalic to felsic, silicic-alkalic rocks of Eocene age.

The extrusive rocks are a wide assortment of flows and flow breccia, pyroclastic deposits and volcanic sediments. The intrusive rocks occur as dikes, sills, plugs, and stocks. The volcanic rocks consist of an irregular assortment and wide variety of mafic and felsic rocks and their intrusive equivalents. The mafic extrusive rocks exceed the felsic in volume.

> "Regional sedimentation in the Bearpaw Mountains region continued from Paleozoic into early Eocene time and ceased with the deposition of channel boulders derived from the Rocky Moutains region to the southwest. Deformation interrupted sedimentation and was followed by erosion and by the irruption of a great variety of intrusive and volcanic igneous rocks in the remaining part of the Eocene epoch. Deformation continued concurrently with igneous activity, but probably ceased in late Eocene time with collapse faulting of the mountainous area. Erosion during the remaining part of the Tertiary developed the present mountainous configuration and established a drainage pattern that was adjusted to the late Tertiary Missouri River system. A continual ice sheet advanced southeasterly across the northern half of the quadrangle in late Pleistocene time, abutted against the high terrain of Number One Mountain and Mount Reynolds, filled the lower stretches of the existing valleys with till, and covered with drift all the pediment surfaces and interstream area below about 4,200 feet in altitude. The present stream courses are largely the result of consequent drainage on ground moraine, and locally, as along Beaver Creek, parts of preglacial valleys have been resurrected. Evidence for more than one ice sheet is[1] not available. Postglacial dissection in some places exceeds 150 feet.

The volcanic rock exposed in the Bearpaw Mountains can be distributed into a northern and southern field, with the volcanic rocks in the area of Bearpaw Dam constituting the central part of the northern field. After volcanism ceased, the rocks were faulted, with the volcanic piles being tilted. Total thicknesses of these volcanic rocks is greater than 10,000 feet.

1.2.3 Seismicity

The inspection guidelines (Ref. 1) seismic zoning map of contiguous state zones shows the Bearpaw Mountain Region between Zones 1 and 2 which are zones of minor earthquake damage. Maximum seismic events in this area are expected to be less than Richter Magnitude 5.0. According to the guidelines, associated ground surface accelerations on the order of 0.025 to 0.05g are anticipated.

1.2.4 Site Geology

The dam has been constructed at a narrow portion of the valley. The narrowing is the result of a resistant extrusive body of mafic volcanic rocks. These volcanic rocks are irregular in form, and appear to consist of flows and pyroclastic deposits, which are cut on the right side of the creek by dark-gray, massive, hard, mafic rock, continuing to the east. A clay, gravel and boulder mixture (glacial till) underlies part of the left side of the dam, while the remainder of the dam foundation and abutments are resting on bedrock. The outlet conduit has been cut into bedrock on

[1] Preliminary Geologic Map of the Shambo Quadrangle, Bearpaw Mountains, Montana. Map 1-236 USGS.

the right side. The left abutment contains a spillway. The spillway exit is volcanic rock, and therefore, little downcutting of the creek has taken place. Since the channel is resistant to downcutting, horizontal widening of the channel has taken place.

A slump or slide has occurred on the left side and approximately 200 feet downstream of the dam. The slide is between two volcanic ridges and has moved downhill into the creek channel. This slide has been cut back by the widening process of the creek and appears stable at this time.

Volcanic rocks are exposed in the reservoir area along with glacial till. Major overburden slides into the reservoir were not evident and are not considered a problem. The shoreline has been undercut by wave action in numerous places, resulting in actively eroding bank faces. Other geologic-related topics are discussed in the geotechnical evaluation.

1.2.5 Design and Construction History

The project was designed in 1954-1955 by the State Water Conservation Board at Helena, Montana. Construction by the Montana Fish and Game Department took place in 1958. Other than a set of construction drawings prepared by the Montana State Water Conservation Board and some correspondence regarding peak flow computations for sizing spillway, there is a lack of comprehensive design data or construction records available.

According to correspondence with the Department of Fish and Game there has been no known inspection or regularly scheduled maintenance performed on the dam. Three years after initial construction a cliff face gave way on the left abutment and damaged the spillway. Six years after construction a car went off the bridge and damaged the spillway. Repairs were made in both cases.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for Bearpaw Lake Dam is an uncontrolled, two-bay reinforced concrete chute located near the left abutment of the dam. The inlet to the spillway is controlled by a modified "ogee" section with an effective crest length of 47 feet. The top of the side walls at spillway entrance are 8 feet above spillway crest elevation 3598.0 MSL. A wood bridge rests on the side walls and a 1.5 feet wide center pier at top of dam. (Photo 4) The discharge channel (chute) has 6 feet high vertical sidewalls and a uniform width of 50 feet. The spillway terminates in a flip bucket energy dissipator. (Plate 7) "As-built" plans show that the designed location of chute centerline was moved 42 feet toward the left abutment during construction. The chute floor rests on excavated foundation of partial glacial till and bedrock. Drainage is provided under the chute floor by drain pipes installed in gravel-sand filters. The bottom of the first bridge stringer which is transverse to flow direction at spillway entrance is approximately 12 inches below top of dam elevation 3606.0 MSL, and is located approximately 14 inches downstream from a vertical line intersecting the "ogee" crest.

This stringer may shear the water surface when lake elevation approaches 3606.0 MSL, however obstruction to flow is slight. In developing the discharge rating, critical depth energy levels for maximum discharge were checked at the location where the side wall height is 6 feet, and the water surface was contained within the chute. The exit channel slope is greater than the critical slope for maximum discharge, and control was found to remain at the spillway crest for all discharges. Spillway discharge rating data was computed using a coefficient of discharge which varied from 3.11 at low head to 3.75 at maximum discharge. A spillway rating curve is shown on Plate 8. The spillway discharge capacity is approximately 3980 c.f.s. with the lake level at the top of the dam, elevation 3606.0 feet MSL. There is no log boom or other protective barrier at the spillway entrance. It was not possible to determine high water marks on side walls at the spillway entrance. The flip bucket impact area at spillway outlet is erosion resistant and shows no signs of serious erosion or downcutting that would affect the safety of the structure. The downstream channel is resistant to downcutting, however horizontal widening has occurred immediately downstream from the spillway outlet.

The field inspection revealed minor cracking in the chute sidewalls in a vertical direction at apparent construction joints. A shallow flow over the chute floor prevented close inspection of the floor, however, there was no evidence of serious erosion, spalling, or cavitation at the junction of sidewalls and floor. Concrete surfaces appeared hard and durable.

2.1.2 Outlet Works

The outlet works for Bearpaw Lake Dam are located near the center of the dam. A reinforced concrete gate tower with center divider wall, houses two 36" X 36" gates at tower base with the upstream gate serving

as a guardian gate and downstream gate used as an operation gate. The gate tower functions as a wet well. The top of the concrete gate well is at approximately 3606.5 feet MSL elevation, and the invert of the tower base is at approximately 3562.0 feet MSL elevation. The outlet conduit rests on bedrock and extends about 160 feet upstream from the gate tower and about 160 feet downstream from the gate tower. The outlet conduit is a monolithic reinforced concrete structure with a "horseshoe" shaped inside cross-section. The level bottom of the "horseshoe" is 36" wide and the height to apex of 18" radius semicircle is 36". (See Plate 3) The invert of the conduit outlet is about 59 feet below top of dam and about 51 feet below crest of spillway. The maximum discharge with lake level at point of overtopping the dam embankment is estimated to be approximately 170 c.f.s.

Outlet discharge rating was developed using the following assumptions:
(a) Friction losses in conduit computed with n = 0.015
(b) Conduit entrance loss coefficient = 0.5
(c) Wetwell tower loss coefficient = 3.0
(d) Conduit exit loss coefficient = 1.0

Inspection of the gate tower was accomplished by opening the downstream gate to flush out sediment, then closing the upstream (guardian) gate. A large amount of sediment was removed by the flushing, indicating that the gate had not been opened for some time. The guardian gate when closed leaked at the top and bottom, and appeared "cocked" slightly indicating that a stick or other debris may have been lodged under one side. The outlet conduit is not used for reservoir management purposes, although capacity was adequate to discharge inflows estimated at 60 c.f.s. at time of inspection.

The monolithic concrete outlet conduit was inspected from the outlet end to the gate tower. Concrete surfaces appeared to be in good condition. There were signs of "weeping" with very minor spalling at vertical construction joints. The conduit outlet structure provides little energy dissipation, however the channel bottom is resistant to downcutting. Some lateral erosion could occur with high discharges. Both slide gates were operated from the tower and were in operating condition. One lift crank was broken and unusable. Inspection of the conduit upstream from the gate tower could not be made since the water surface in the wet well was approximately 3598.5 feet MSL. (Plate 6)

2.1.3 Freeboard

The dam overtops during the recommended spillway design flood (see Paragraph 2.2.4), so it has no freeboard. The spillway was flowing at approximately 0.5 feet depth on the crest at the time of inspection. The spillway crest is at elevation 3598.0 feet M.S.L. and the top of the dam is 8 feet above spillway crest. There are no visible signs of high water marks on the sidewalls of the spillway.

The fetch for wind generated waves is less than 1,000 feet, and wave runup on the embankment is estimated to be less than 2 feet. The vertical distance between the dam crest and normal reservoir level is adequate to prevent overtopping the embankment by wind waves.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The Bearpaw Lake drainage (Ref. 2) comprises approximately the upper half of the Beaver Creek drainage in north central Montana in the southeastern part of Hill County. The drainage covers approximately 49 square miles, is approximately 14 miles long, and averages 3.5 miles in width. Beaver Creek, the main tributary to Bearpaw Reservoir, heads in the north central part of the Bearpaw Mountains at an elevation of 6942 feet MSL and flows north to the Milk River about 2-1/2 miles west of the City of Havre at an elevation of about 2480 feet. Elevation of Bearpaw Reservoir is about 3600 feet MSL. Latitude at center of basin is $48^{o}15'$ and longitude is $109^{o}41'$.

Average annual June through October precipitation at the Rocky Boy's permit No. 2 precipitation station (Elevation 5200 ft.) is 12.34 inches, 60% of which occurs during May and June. An additional 4.5 inches of average April 1 snowpack water equivalent is observed, bringing the total average annual precipitation at Rocky Boy to about 16.9 inches. Temperature variations are extreme in this region ranging from $100+^{o}F$ in summer to $-40^{o}F$ in winter months. The average annual frost-free period is 139 days with the last day of frost occurring in late May or early June. Average annual lake evaporation is approximately 38 inches of which 80% occurs during May - October.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 36 acres and a storage of 535 acre-feet at emergency spillway crest, elevation 3598.0 feet M.S.L. Approximately 370 acre-feet of surcharge storage is available in the reservoir between the emergency spillway crest and the dam crest elevation 3606.0 feet M.S.L. The chute spillway discharge with the reservoir at dam crest is about 3980 c.f.s. A spillway discharge rating curve is shown on Plate 8.

2.2.3 Estimated Probable Maximum Flood (PMF)

The probable maximum flood (PMF) is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF for Bearpaw was developed using the HEC-1 Flood Hydrograph-Dam Safety Investigation Computer Program. (Ref. 3) Primary program input consisted of the 72 hour probable maximum precipitation (PMP) which was obtained for the study site from Ref. 4. Generalized estimates of 10 square miles PMP for durations of 1, 6 and 24 hours were obtained from charts in Ref. 4 and subsequently adjusted based on a drainage area size of 49 square miles. The 24 hour PMP was determined to be 16.80 inches. PMP values for 48 and 72 hour durations were estimated as 110% and 115% respectively of 24 hour PMP. A depth-duration curve was plotted from which one hour incremental rainfall values were determined and subsequently arranged in a critical sequence according to Ref. 5. Total precipitation for 72 hour period was 19.32 inches with a maximum hourly value of 6.15 inches.

The PMF hydrograph was based on a one-hour unit hydrograph (UHG) constructed using procedures outlined in Ref. 6. In calibrating the SCS unit hydrograph for input to HEC-1 a basin time of concentration of

2.4 hours was used along with an incremental storm duration of one hour. Combination of the cricital PMP sequence with the UHG resulted in the PMF inflow hydrograph to Bearpaw Reservoir. Because the reservoir surface area is small by comparison with drainage area (55 acres vs 49 square miles) no attempt was made to consider precipitation falling on reservoir surface as a separate calculation. It was assumed that frozen soil conditions prevailed during the PMP resulting in an infiltration rate of zero.

The resulting PMF peak inflow to Bearpaw Reservoir was found to be 96,800 c.f.s. while total inflow volume was 50,500 A.F.

2.2.4 Flood Routing

Routing of the estimated PMF hydrograph developed for this study through Bearpaw Lake Dam project was accomplished by means of the computer program, HEC-1. (Ref. 3) Initial water surface elevation in the reservoir was assumed to be at spillway crest elevation 3598.0 feet MSL at the onset of the PMF. Routing was accomplished using the modified puls method.

Routing studies indicate that:

a. During the full PMF the dam would be overtopped when approximately 9 percent of the total flood volume enters the reservoir.

b. Routings were made of hypothetical floods less than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph corresponding to 5 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

A possible breach of the upstream East Fork Reservoir Dam was not considered in the total flood volume entering Bearpaw Lake during the PMF. However, the drainage area above East Fork Reservoir, 3.2 square miles, was included in the development of the PMF for Bearpaw Lake Dam.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam Embankment

The dam is a zoned earth embankment 59 feet high, with a crest length of 380 feet, and an effective top width of 18 to 20 feet.

The upstream slope is 1V on 3H and the downstream slope is 1V on 2H. Construction procedures and source of embankment materials is unknown. Reservoir topography indicates borrow may have been taken from the area upstream from the right abutment.

According to construction drawings, the zoned embankment has an impervious center zone backed by a semi-impervious fill downstream. The downstream shell, composed of sand, gravel and rocks, extends to the top of the dam from the downstream toe, with a 1V on 1H slope against the semi-impervious fill, and 1V on 2H exterior slope. The upstream slope of impervious fill is confined with a layer of sand, gravel and boulders. A

typical section of the dam is shown on Plate 5. The relative strengths, density, permeability and drainage characteristics of the zoned embankment are unknown, as are construction methods utilized.

The field inspection showed that riprap on the upstream slope consists of gravel to boulder size volcanic agglomerate. The riprap is in poor condition due to weathering action, with many of the cobbles and boulders broken down. (Photo 9) Large areas (two to three square yards) consist only of gravel size agglomerate fragments. Although riprap was originally placed to the crest of the dam, portions have been dragged below pool level, possibly by ice action. (Photo 1) This is particularly apparent near the spillway, where a section of riprap has been dragged below normal pool level giving the impression of a slump. Closer inspection revealed there is no slump. A small slump was noted in natural ground near the left abutment on the upstream slope of the reservoir. (See Photos 10 and 11 and Plate 3) Reportedly, the slump resulted when new riprap was placed in this area. The added weight apparently exceeded the shear strength of the underlying saturated soil mantle, with consequent slope failure. The slump appears to be localized and is backed by a thick section of the abutment.

The downstream slope of the dam appeared reasonably smooth and uniform. It is covered with grass, scattered small bushes, and a few small cottonwood trees. (Photo 2) Visible near-surface downstream slope materials consist of sand and clay, with occasional cobble-size rocks. There is a small surface erosion gully on both sides of the spillway, running its entire length. This eroded area is apparently being used as a footpath. (Photos 5 and 6) There was no visible sign of unusual settlement or cracking in the dam embankment which would indicate distress. The slump near the left abutment is in natural ground rather than embankment, and does not appear to present a hazard to overall stability. The crest of the dam is used as a roadway. When wet from precipitation, it ruts and becomes very slippery. Grader maintenance may have a tendency to "wear" down the top of the dam embankment. A profile of the dam crest surveyed at the time of inspection shows reasonably uniform grade, with no severe undulations in profile (Plate 4). However, care should be exercised to maintain top of dam elevation.

2.3.2 Foundation Conditions, Seepage and Drainage

Examination of the boring logs and "as-built" plans indicate that part of the embankment near the left abutment is founded on a topographic nose extension of the abutment composed of clay, gravel and boulders. (Plate 4). A cut-off trench or key was reportedly excavated into the foundation and abutments upstream from centerline of dam. The trench, approximately 20 feet wide with variable depths, is excavated into bedrock on the right side of the embankment foundation and into dense clay, gravel and boulders on the left side. The right abutment is composed of dense clay, gravel, and boulders overlying bedrock.

At the downstream toe a small seepage area was noted just above the conduit outlet. (Photo 7) Further investigation revealed that this seepage area is the exit point for an 8-inch concrete drain pipe, shown on the "as-built" plans. The drain pipe follows the trough of the downstream toe from the right abutment and terminates just above the conduit outlet. The drain was installed at the time of construction, and reportedly drains a

small spring that existed before construction. A small trickle was observed flowing from the pipe. Tree roots may be clogging the drain line.

"As-built" plans show that several modifications of design were made during construction, presumably to provide more integrity of dam embankment, spillway and outlet structures against potential settlement and seepage. The design spillway location was moved toward the left abutment and is founded on bedrock or dense clay, gravel, and boulders for its entire length. Very little settlement is apparent in the spillway structure, and there is no evidence of compression of joints in the side walls. The base of the outlet works and gate tower were lowered 4 feet from design elevation, apparently to rest on the more stable bedrock foundation. Additional anti-seep collars were added to the conduit to lengthen the path of seepage.

2.3.3 Stability

The dam has operated since construction with normal water surface at or near spillway crest elevation 3598.0 MSL with no reported problems. Maximum water levels are unknown; however, with the capacity of the chute spillway, water levels would rise only during major floods, and would be maintained for short periods of time.

No stability analysis of the dam is on file. The effects of seismically induced ground motion on the gate tower and embankment have also not, to our knowledge, been analyzed. However, the probability of a seismic event occurring with the intensity and duration required for failure would be remote. There is insufficient data on soil strengths or piezometric surfaces to assess the dam stability.

2.4 PROJECT OPERATIONS AND MAINTENANCE

2.4.1 Dam

There is no formal plan for operation and maintenance of Bearpaw Lake Dam. According to Mr. Christianson the low level outlet is normally opened for several hours once a year to make sure it is operating properly. Obvious repair needs are taken care of as the need arises. It is reported that the chute spillway was damaged on two separate occasions. Once when a cliff face gave way, and once when a car went off the bridge. Repairs were made in each case.

2.4.2 Reservoir

The lake level is uncontrolled throughout the year. The spillway operates annually and is uncontrolled with gates or stoplogs. Reservoir levels are maintained at or near spillway crest elevation 3598.0 feet MSL. It is reported that the reservoir was drawn down in September, 1979 for fisheries management purposes.

2.4.3 Warning System

There is no formal warning system or plan for use in the event of impending dam failure.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by evaluation of available data and analysis of the project in terms of the recommended guidelines performance standards, resulted in the following findings.

3.1.1 Size, Hazard Potential, and Safety Evaluation

The 59-foot-high Bearpaw Lake Dam impounds about 905 acre-feet of water with the reservoir at dam crest, and in accordance with inspection guidelines (Ref. 1) is classified as intermediate in size. Based on visual inspection and judgment the project has a significant (Category 2) downstream hazard potential.

Inspection guidelines recommend that the spillway design flood (SDF) for a project of this type range from one-half to the full PMF. Due to lack of residences immediately downstream a SDF of 1/2 PMF is recommended. An estimate of the PMF made during this dam safety study indicates that the dam will be overtopped during the PMF when only 9 percent of the total flood volume enters the reservoir. A hypothetical flood with 5 percent of the PMF ordinates is just controlled by the project.

The impact of possible overtopping and failure of Bearpaw Lake Dam on the downstream Beaver Creek Reservoir Dam during the routing of the recommended spillway design flood is undetermined. Hydrologic studies are urgently needed to define the detailed spillway design flood so that routings, including possible overtopping and failure of Bearpaw Lake Dam, can be made to fully evaluate the impact on Beaver Creek Reservoir Dam. Because the project is incapable of handling 1/2 the PMF, Bearpaw Lake Dam does not meet inspection guidelines.

3.1.2 Spillway

Visual inspection of the reinforced concrete chute spillway showed the structure to be in reasonably sound condition with no evidence of settlement or displacement of joints. The floor of the chute could not be examined closely due to a shallow depth of flow over spillway at time of visit. However, no serious flow irregularities were observed that would indicate problems in alignment or local spalling or cavitation. A high water line or evidence of high flows could not be detected by visual observation. The flip bucket impact area immediately downstream from the structure shows no signs of serious erosion that would affect the safety of the structure.

3.1.3 Outlet Works

The valve tower and gates appear in good condition. The upstream or guardian gate leaked at top and bottom when fully closed. One lift crank was broken. The large amount of organic sediments at the bottom of the gate well and algae on the gate stems indicated that the gates had not been operated in some time.

The reinforced concrete conduit downstream from the gate tower appeared in good condition, with very minor construction joint opening or displacement. Accumulations of salt crystals near the bottom of small

cracks at construction joints indicate further infrequent use of outlet works. Inspection of the monolithic concrete conduit upstream from the guardian gate could not be made.

3.1.4 Spillway and Reservoir Capacity

The reservoir has a surface area of about 36 acres and a storage of 535 acre-feet at spillway crest elevation 3598.0 feet MSL. Approximately 370 acre-feet of surcharge storage is available between the spillway crest and dam crest. The discharge capacity of the chute spillway, with the reservoir at the dam crest is approximately 3980 c.f.s. The low level outlet has a capacity of approximately 170 c.f.s. with reservoir level at dam crest, and with gates fully open. The gate control house is accessible with reservoir levels at dam crest 3606.0.

3.1.5 Dam Embankment

Visual inspection of Bearpaw Lake Dam revealed no visible sign of unusual settlement or serious cracking that would indicate distress. The downstream embankment slopes appear reasonably uniform and free of damaging seepage. It is well covered with grass, scattered small bushes, and a few small deciduous trees. A small surface erosion gully runs the entire length of the spillway adjacent to spillway walls on both sides, with the left side most pronounced. These eroded areas appear to be used as footpaths.

The crest of the dam is used as a roadway, and is maintained occasionally with a grader. There are no severe undulations in profile, however, grader maintenance appears to "wear" down the top of the dam embankment. Riprap on the upstream slope is in poor condition due to weathering action. Portions of the riprap appears to have been dragged down below normal pool elevation leaving exposed embankment, particularly in the area at the spillway entrance. The normal pool free board (7+ feet) is adequate to prevent wind-generated waves from overtopping the dam.

A small slump was noted on natural ground upstream from the left abutment, and near the shoulder of the road. The slump has apparently resulted from added weight of new riprap placed in this area. The slump is away from the dam embankment and is backed by a thick section of the rock abutment. It does not endanger dam stability, however, repairs need to be made to protect the shoulder of the road.

3.1.6 Geotechnics - Foundation Conditions, Seepage and Drainage

The dam is tied to bedrock on the right abutment and partially at its foundation. The remainder of the dam is founded on glacial till. A cut-off trench was reportedly excavated into the foundation and abutments. It was excavated in bedrock on the right abutment and foundation, and into dense clay, gravel and boulders on the left abutment. No damaging seepage was noted in the foundation or embankment at the toe of the dam. A drain pipe on the right abutment, which apparently drains a small spring located under the downstream toe of the dam at foundation contact appeared to be functioning. However, the drain tile may be susceptible to clogging with tree roots due to its location. Foundation strengths appear to be adequate for the height of dam, however precise information on strength, parameters is not available to verify. Settlement appears to be minor.

3.1.7 Stability

No stability analysis for Bearpaw Lake Dam is on file, and there is insufficient information on soils parameters and position of the phreatic line to evaluate embankment stability.

3.1.8 Operation and Maintenance

There is no formal plan for operation and maintenance of Bearpaw Lake Dam. Repairs have been made on a timely basis as the need arises. Low level outlet gates are normally opened for several hours once a year to test operation adequacy. The lake level is uncontrolled throughout the year.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

1--Develop, implement, and test an emergency warning plan for use in the event of impending dam failure. It is imperative that the warning plan be coordinated with the emergency warning plan implemented for East Fork Dam upstream and Beaver Creek Reservoir downstream from Bearpaw Lake on Beaver Creek drainage.

2--Inspect the outlet conduit in its entirety. Repair as required.

3--Provide upstream slope protection by upgrading rock quality and replacing riprap.

4--Repair slough on upstream face of left abutment.

5--Remove all trees, brush, and root systems from embankment slopes, fill voids with granular material and compact.

6--Operate gates on outlet works through their full range of operation at least twice annually. Replace broken lift crank.

7--Repair and maintain the dam crest at or slightly above design elevation.

8--Remove clusters of floating debris and logs around the reservoir perimeter throughout the operating range of the reservoir. Develop a plan to prevent spillway blockage by debris.

9--Conduct more detailed hydrologic and hydraulic routing studies taking into account upstream and downstream dams, to better determine the downstream hazard and required spillway capacity. Modify the project as studies indicate. Give consideration to development of a reservoir management plan, which utilizes snow pack and runoff data supplied for management of Beaver Creek Reservoir on a continuing basis.

10--Conduct and place on file, a stability analysis of the dam embankment. We recommend these analyses be performed by a qualified geotechnical engineer and be based on: static loading conditions; in situ strength properties of the embankment, foundation and abutment materials; and phreatic surface conditions. Establish the material strength properties by drilling and sampling with laboratory testing as appropriate, and obtain the phreatic surface by installing and monitoring piezometers.

11--Prior to performing engineering studies and remedial construction that may be required, coordinate the work with the State of

Montana Department of Natural Resources and Conservation.

12--Develop and implement a periodic maintenance plan for the project. Conduct inspections of Bearpaw Lake dam at least every 5 years by qualified engineers experienced in earth dam design and construction.

REFERENCES

1. U.S. Army Corps of Engineers, Office the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C.; Department of the Army, May 1975.

2. Hill County Soil and Water Conservation District et.al., Watershed Work Plan Beaver Creek, Hill County, Montana, Sept. 1967.

3. U.S. Corps of Engineers, HEC-1 Flood Hydrograph Package Dam Safety Investigations, Davis CA, Sept. 1978.

4. U.S. Weather Bureau, Technical Paper No. 38 - Generalized Estimates of Probable Maximum Precipitation for United States West of 105 Meridian, 1960.

5. U.S. Weather Bureau, Hydrometerological Report No. 43 - Probable Maximum Precipitation Northwest United States, November 1966.

6. Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology, 1972.

7. U.S. Bureau of Reclamation, Design of Small Dams, Second Ed. 1974.

8. U.S. Soil Conservation Service, Hydrology of Beaver Creek, Havre, MT. In house report, Bozeman Office, 1967.

9. Christian, Spring, Sielbach and Associates. Phase 1 Dam Safety Inspection, Beaver Creek Reservoir Dam, first draft, August, 1979.

PHOTO 1 - Upstream slope Bearpaw Dam
Gate Tower top center 6/19/79

PHOTO 2 - Downstream slope
Downstream left abutment 6/19/79

PHOTO 3 - Looking downsteam; chute spillway
Note convergence of outlet channel 6/19/79

PHOTO 4 - "Ogee" crest and bridge
Flow estimated 60 C.F.S. 6/19/79

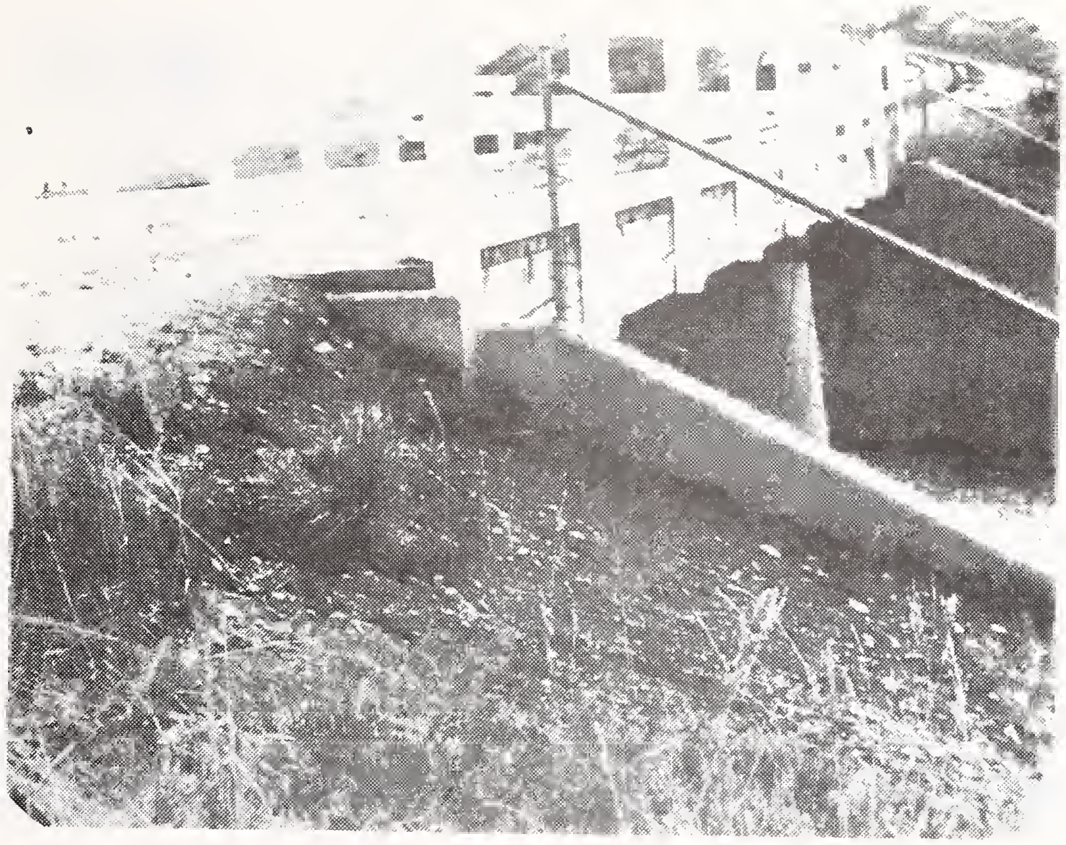


PHOTO 5 - Right Side Chute Spillway
6/19/79

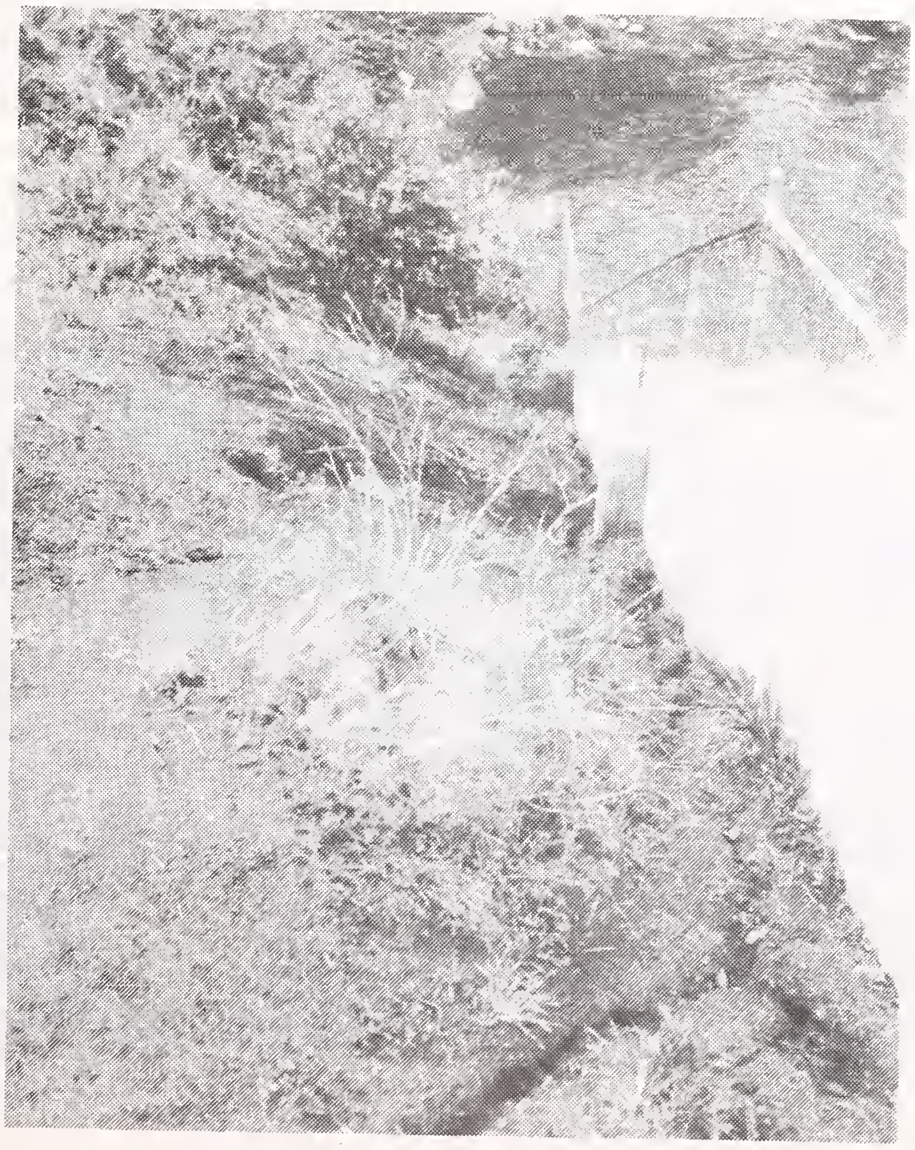


PHOTO 6 - Left Side Chute Spillway
6/19/79

PHOTO 7 - Just downstream from conduit outlet showing seepage (dark line area left side photo) outlet for 8" diameter drain

PHOTO 8 - West shoreline reservoir

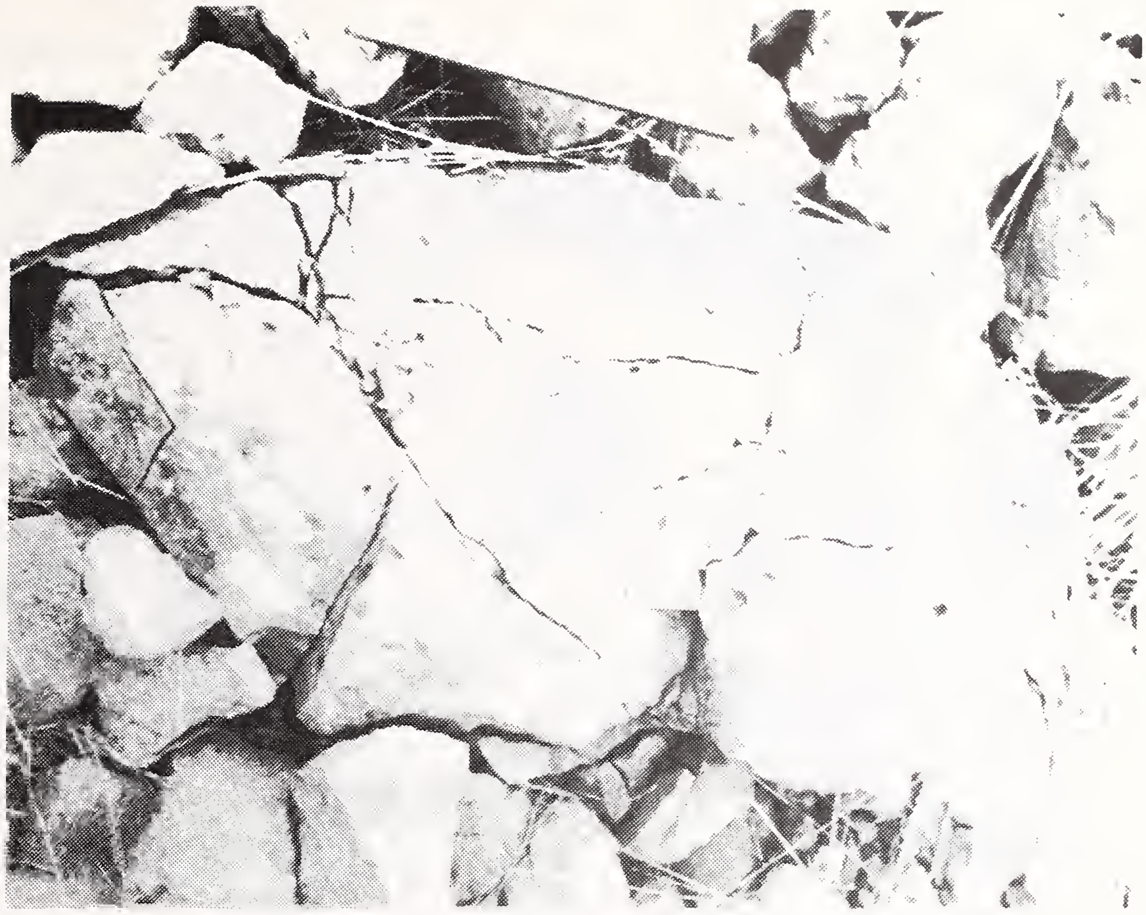


PHOTO 9 - Freese thaw breakdown of riprap

PHOTO 10 - Slump upstream left
(east) abutment

PHOTO 11 - Closer view slump
upstream left abutment

PHOTO 12 - Downstream side of 36" x 36"
Armco 50-10 Slide Gate

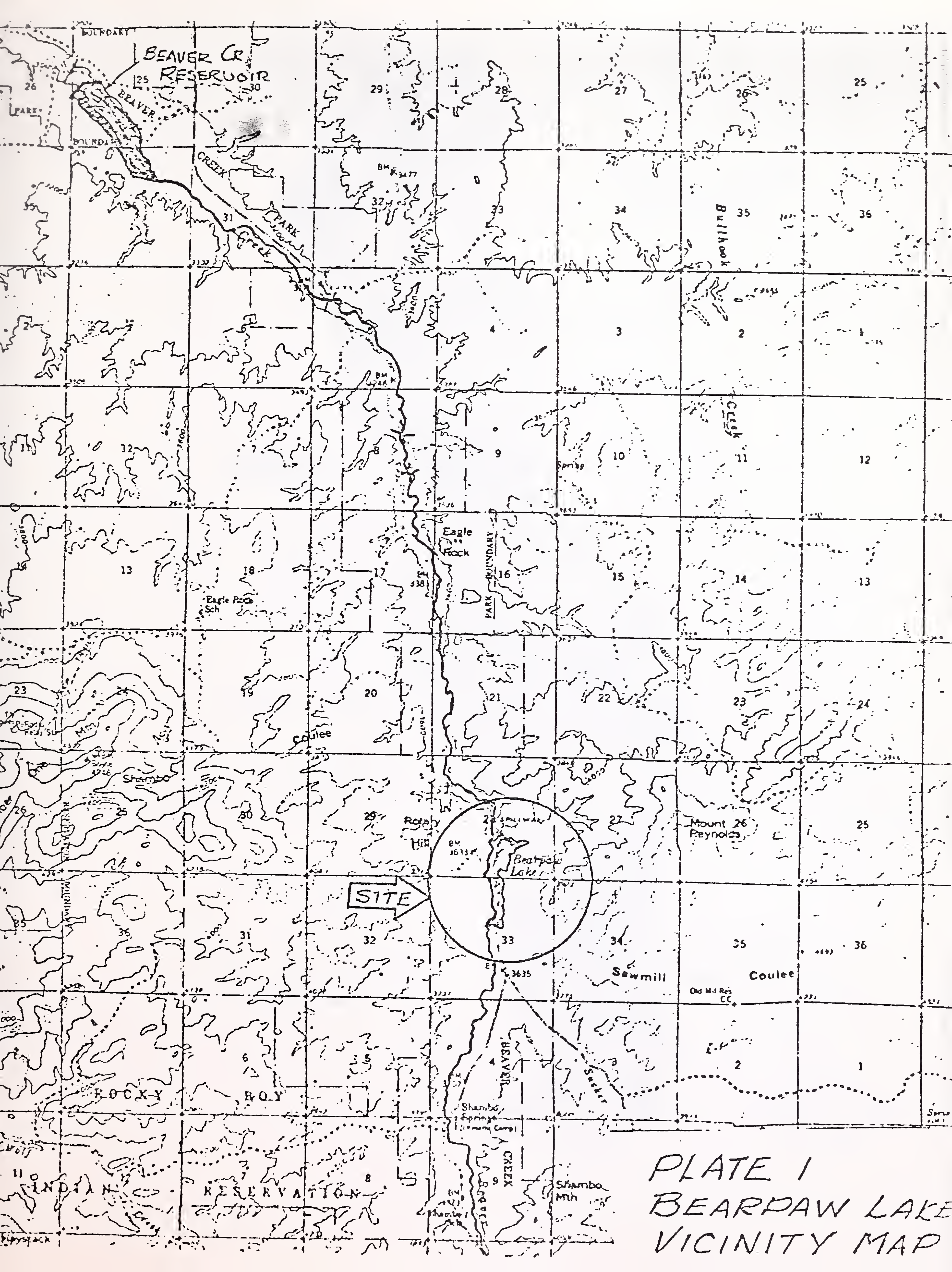


PLATE I
BEARPAW LAKE
VICINITY MAP

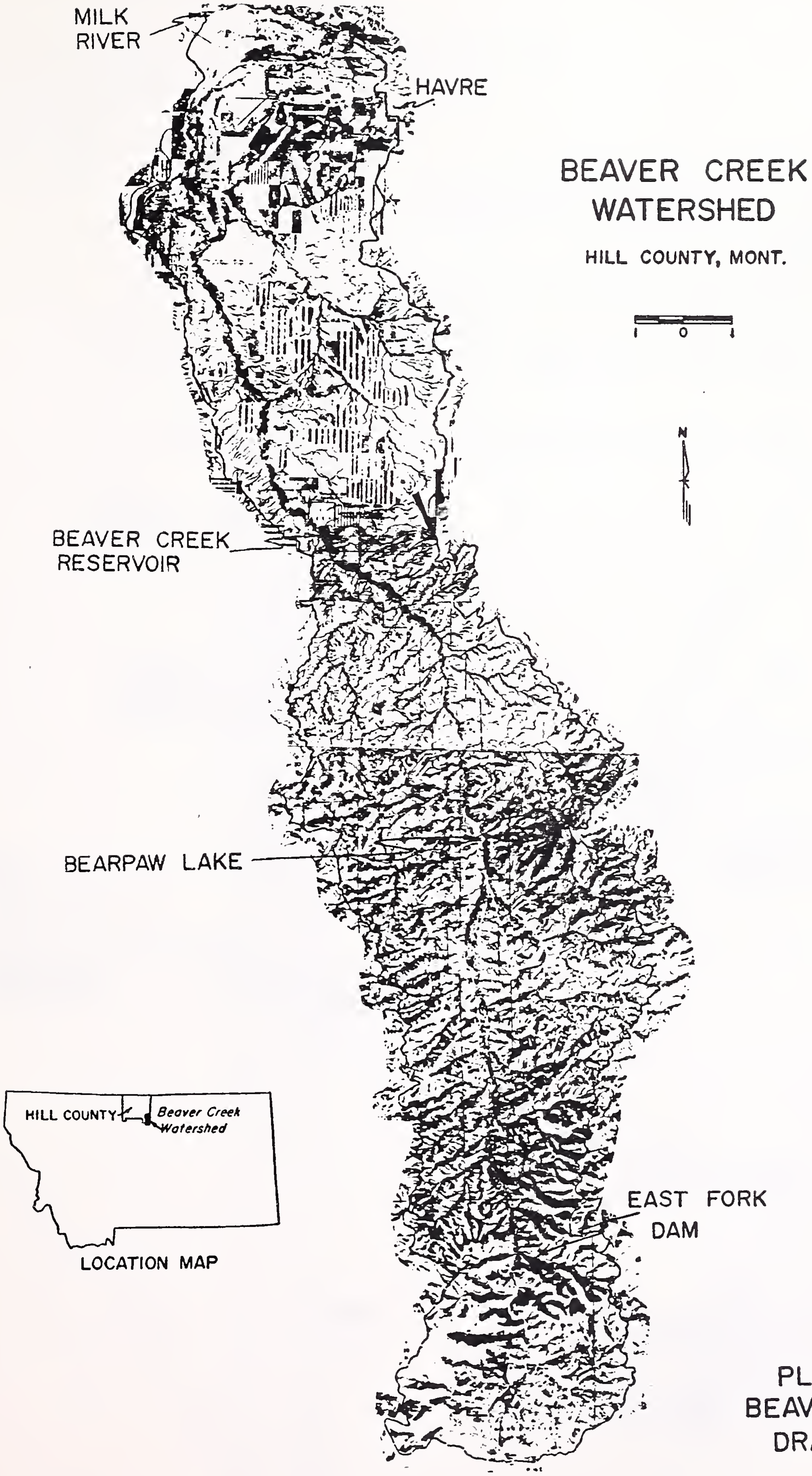


PLATE 2
BEAVER CREEK
DRAINAGE

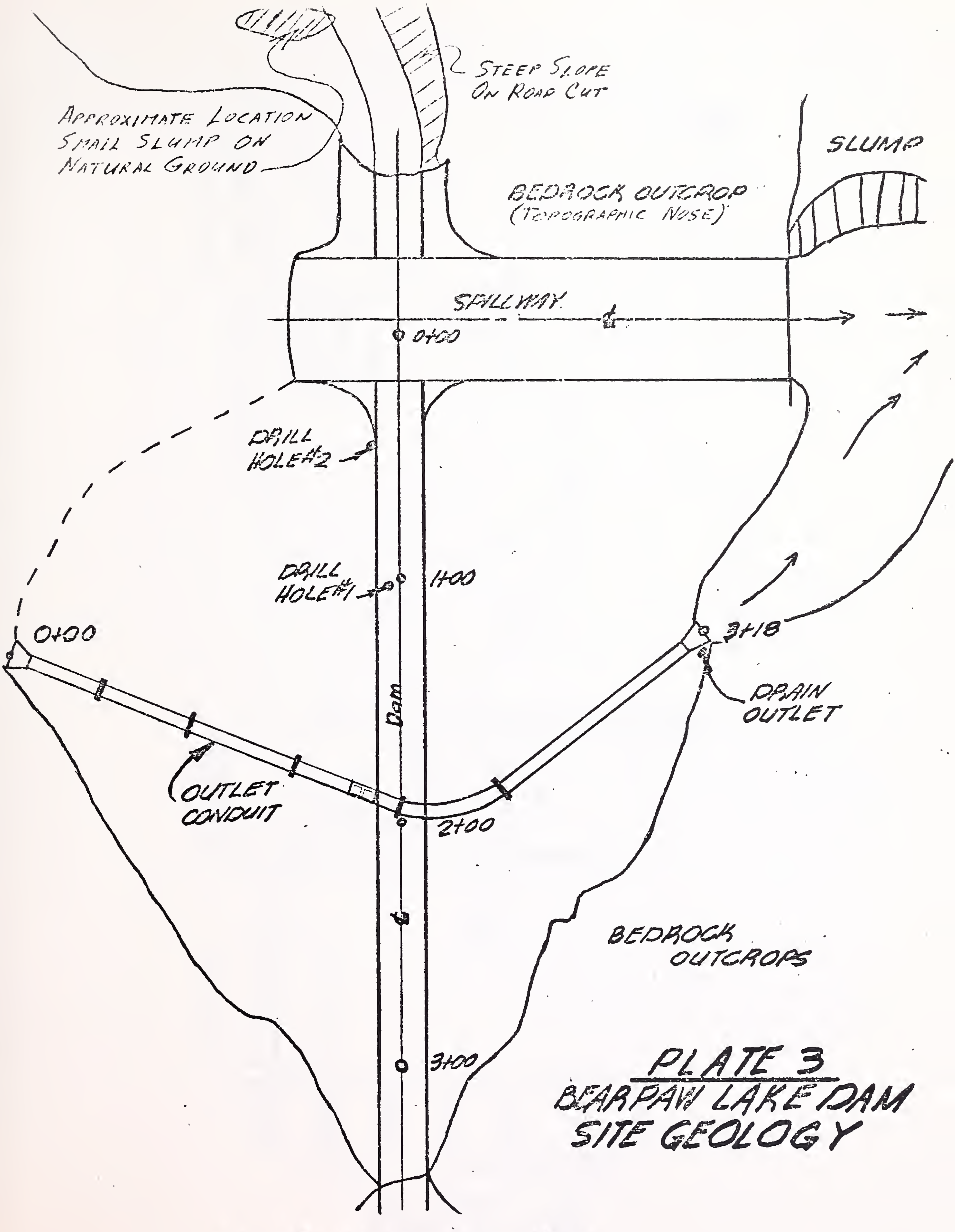


PLATE 3
BEARPAW LAKE DAM
SITE GEOLOGY

SITE PLAN OF DAM

SCALE: 1" = 50'

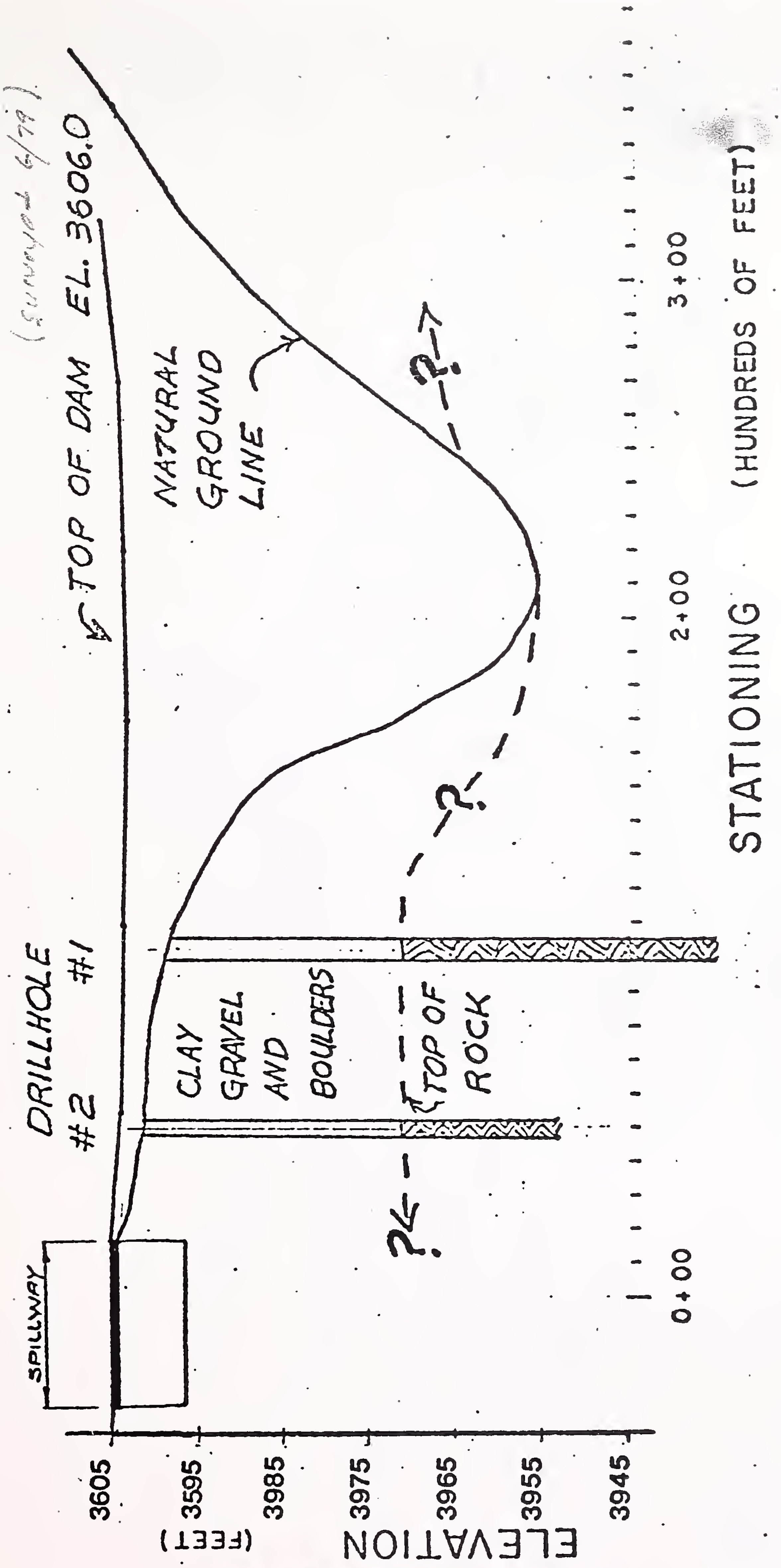


PLATE 4

PROFILE - BEARPAW LAKE

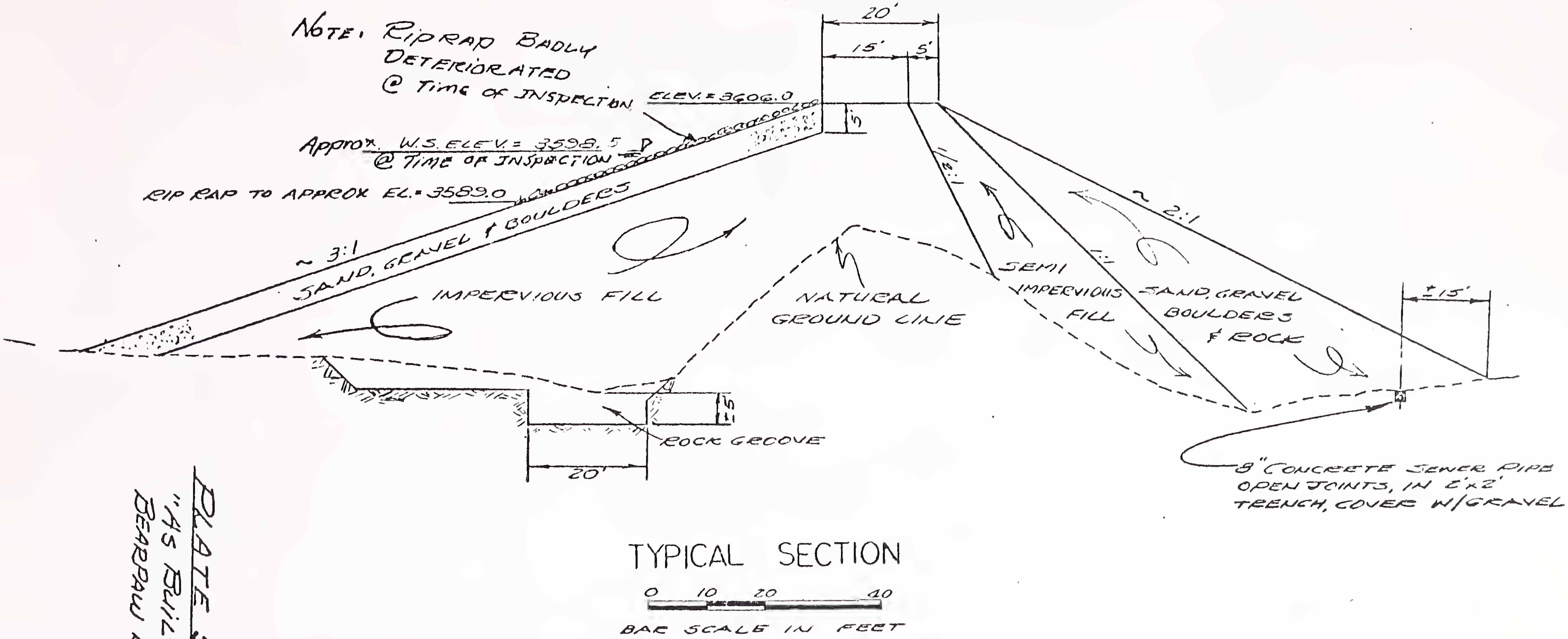
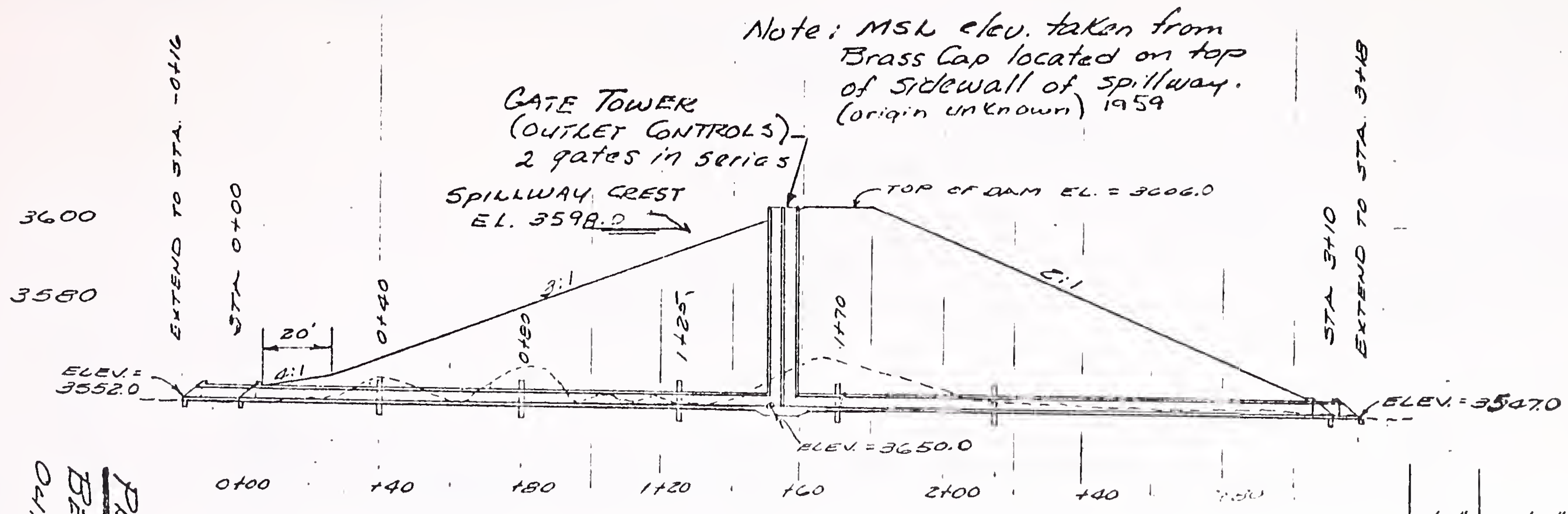


PLATE 5
"As Built"
Bearpaw Lake Dam.

PLATE 6

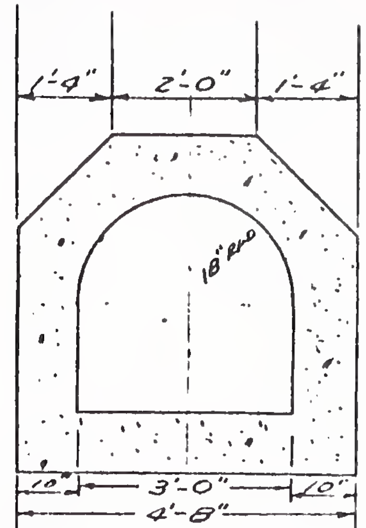
BEAR PAW LAKE DAM
OUTLET CONDUIT



PROFILE OF CONDUIT

0 20 40 80

BAR SCALE IN FEET



OUTLET CONDUIT

0 1 2 4

BAR SCALE IN FEET

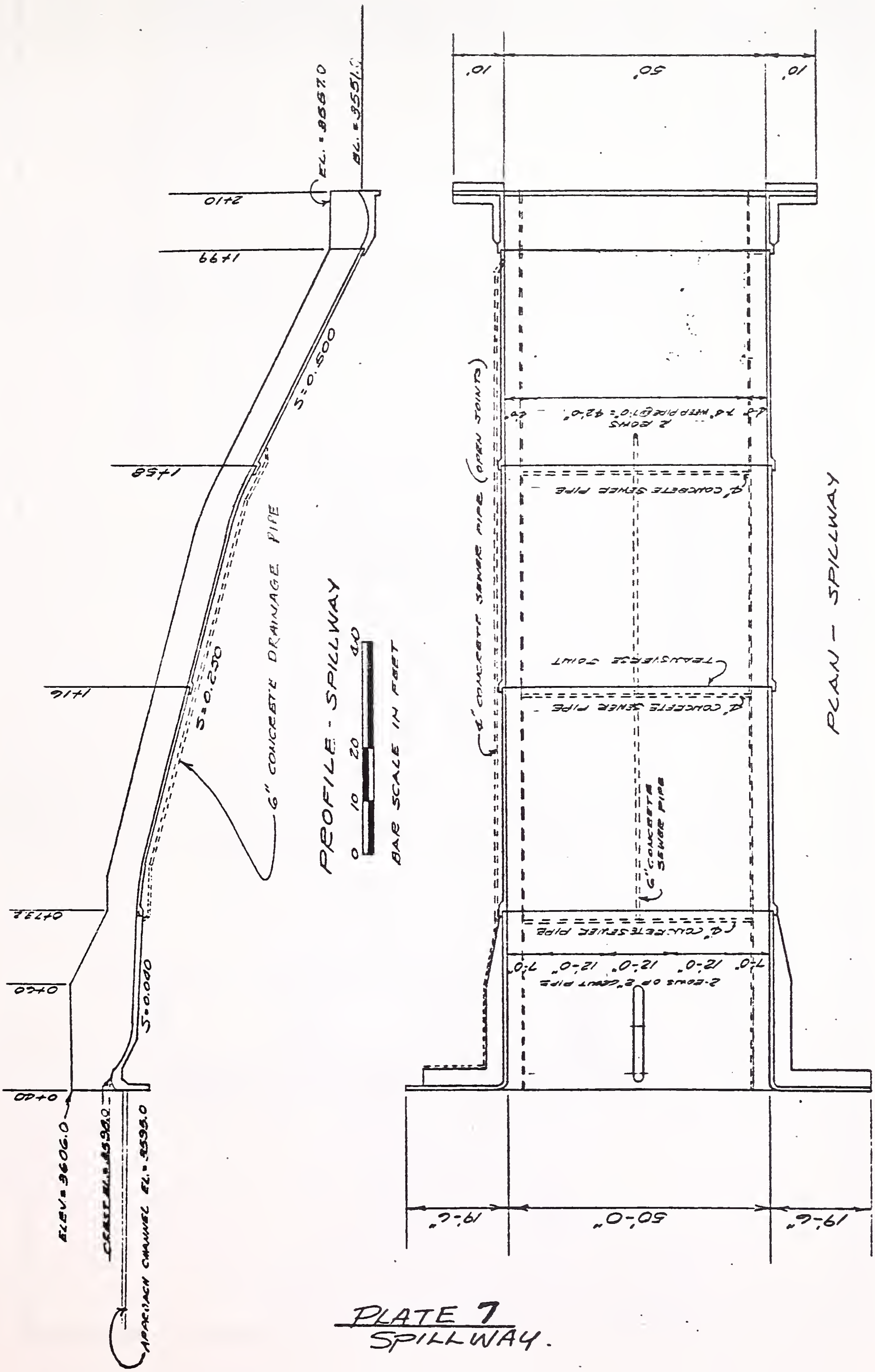


PLATE 7
SPILLWAY.

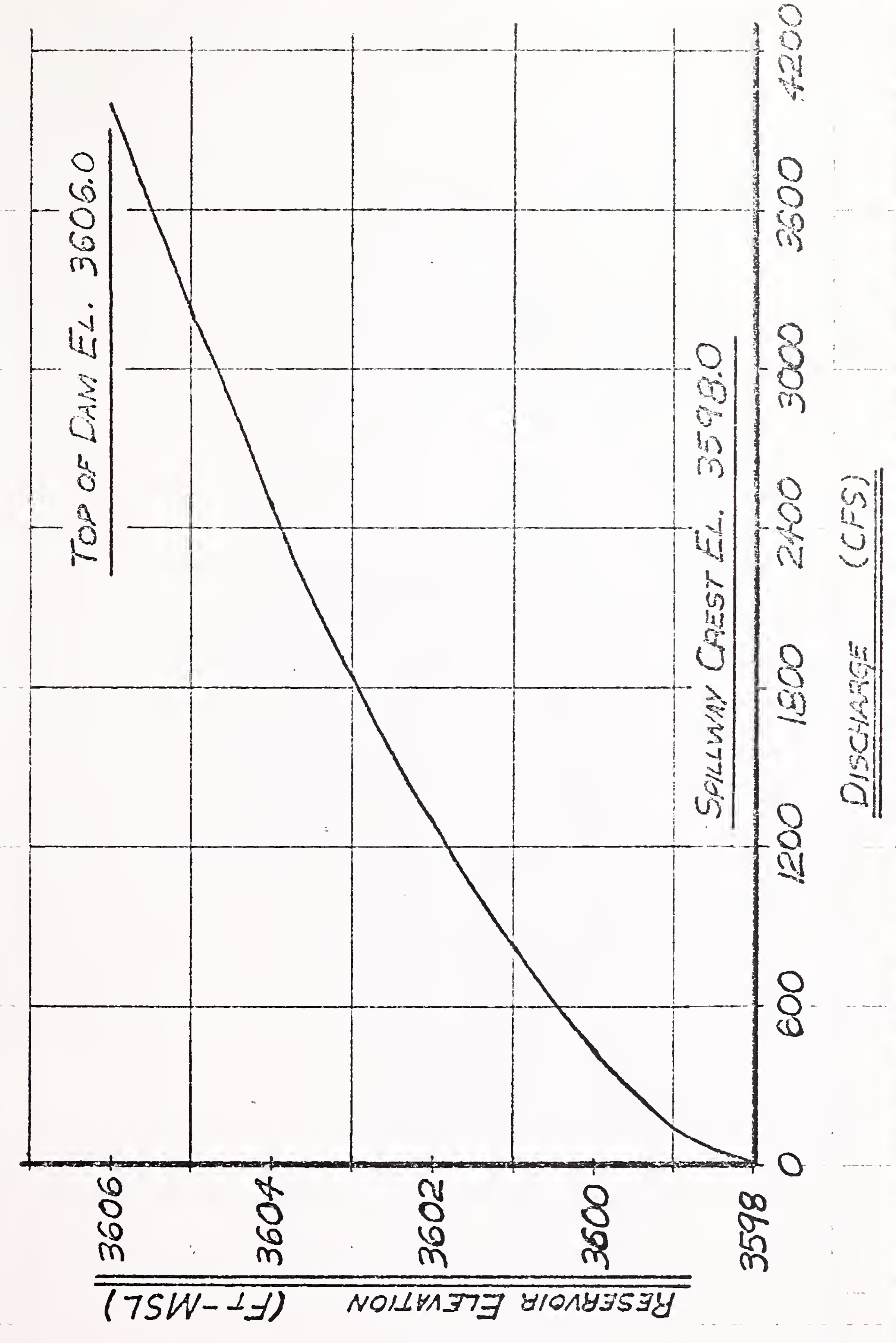


PLATE 8

BEARPAW LAKE DAM
SPILLWAY RATING CURVE

APPENDIX A

STATE OF MONTANA

DEPARTMENT OF

FISH AND GAME

Helena, Montana

Aug. 20, 1980

Mr. Sidney Knutson
Dept. of the Army
Seattle District
Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Sir:

We have completed our review of the Dam Safety Report for Bearpaw Lake (MT-115). Our comments follow:

1. The hazard classification would appear to be high. It has been classed as having significant hazard potential. Reasons stated are that lives of recreationists could be endangered. The guidelines specifically state that the significant category requires human habitations. As far as economic loss; the road that would be endangered is just over 6 miles in length and the bridges on it are very minor structures. The cost of rebuilding the road would, in our estimation, be less than the cost of spillway modifications at the classification assigned.

2. The dam is classed as being intermediate in size. While its height is above 40 feet we feel that the existence of another, newer dam just downstream should be considered. This reservoir would tend to cushion any rapid breach and would eliminate the hazard of any possible wall of water.

3. We realize that the PMF is established according to guidelines laid down by the Corps of Engineers. However, a PMF of 96,800 cubic feet per second is only slightly smaller than the maximum flow ever recorded in the Missouri River just upstream of Fort Peck Reservoir. The maximum in the Milk River at Havre was 20,000 CFS.

4. The discharge capacity of the spillway has been listed as 3980 CFS. This is approximately equal to the average flow in the Yellowstone River at Livingston, Montana.

5. How accurate is the data and consequently the figure given for the time of concentration on page 16?

6. Historically you state that "60% of the precipitation occurs in May and June." (See page 14). This being the case, why was it assumed that the ground would be frozen?

7. Why were no reduction factors applied to the PMF? The guidelines indicate that these factors should be applied.

8. On page 16 and 17 items a. and b., on the surface, appear contradictory. Will it overtop at 5% or 9%?

9. The guidelines call for the engineer to give his opinion on the urgency of correcting each deficiency found. This has not been done.

Overall this entire report and federal program appears to be extremely conservative.

Hopefully, this report can be tempered with some economic common sense with which our Department can live.

Sincerely,

Ron Holliday

Ron Holliday
Administrator
Parks Division

RH:SJ:an

cc: Dick Johnson
Dick Mayer

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE. GOVERNOR 32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 HELENA, MONTANA 59601

August 28, 1980

Rəlph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Wa 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on Bearpaw Lake Dam (MT-115). We concur with the findings and recommendations and feel that the report satisfies the criteria for the Phase I evaluation. Minor comments have been discussed with your staff and we understand that these will be included in the final report.

Thank you for this opportunity to review and comment on the final draft report for this project.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/LT/lj

United States Department of Agriculture
Soil Conservation Service
P.O. Box 970
Bozeman, MT
59715

October 9, 1980

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft report on Bearpaw Lake Dam, Montana (MT-115).

We have no specific comments to make other than there has been no known SCS involvement in the design, construction, and maintenance of this structure.

We do not agree with the hydrology criteria used to develop the probable maximum flood.

Sincerely,

For Van K Haderlie
State Conservationist

cc:
Homer Moore, State Conservation Engineer, SCS, Bozeman
Dave Jones, Environmental Engineer, SCS, Bozeman

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

NPSEN-FM

7 OCT 1980

Ron Holliday, Administrator
Parks Division
State of Montana
Department of Fish, Wildlife and Parks
Helena, Montana 59601

Dear Mr. Holliday:

Thank you for reviewing and commenting on the Phase I Bearpaw Lake Dam safety inspection report draft.

The inspection criteria used for this project were those established by the "Recommended Guidelines for the Safety Inspection of Dams," which represents the comprehensive consensus of the engineering community. The size of the recommended spillway design flood (SDF) of 1/2 the Probable Maximum Flood (PMF) was determined, as the guidelines outlined, by the dam's hydraulic height (59 feet), reservoir size and downstream hazard potential of the project. Because of the limited scope of a Phase I dam safety inspection, the downstream hazard potential rating must be based on a site visit and engineering judgment. In the case of Bearpaw Lake Dam, both the inspecting Architectual-Engineering firm and the State of Montana Department of Natural Resources and Conservation (DNR & C), Office of Dam Safety, concur in the "significant" rating. Also, the DNR & C Office of Dam Safety concurs in report recommendations.

In regards to the PMF derivation, it was estimated, based on accepted procedures for a reconnaissance level of study such as a Phase I inspection and, although floods approaching the probable maximum flood (PMF) may never have been historically experienced in the project area, represents what could happen. It is recognized that refinements in the preliminary PMF could either increase or decrease the final flood estimate; consequently we recommended further hydrology and hydraulic studies that take into consideration upstream and downstream storage projects.

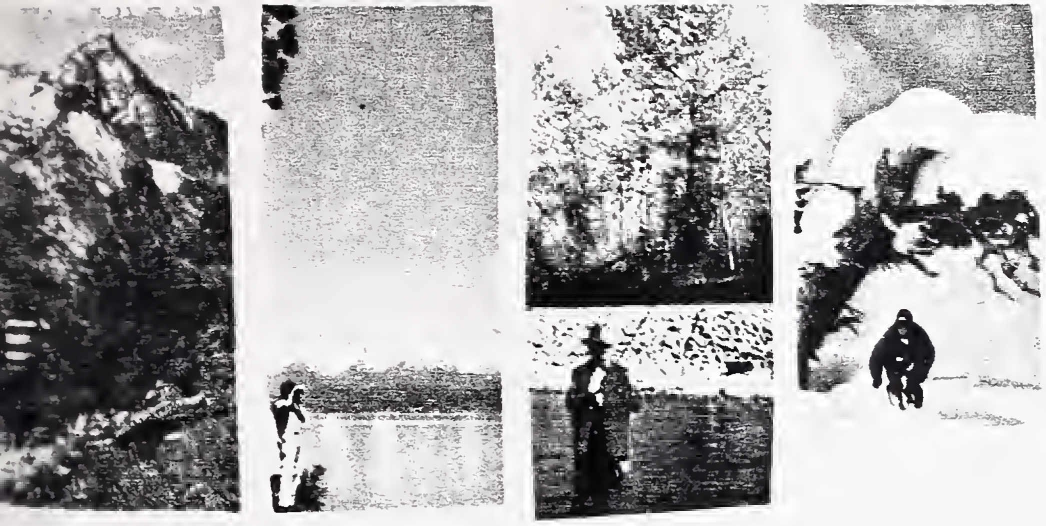
Flood routing studies show that, if a PMF were to occur, the dam would be overtopped when approximately 9 percent of the total PMF volume had entered the reservoir. To obtain a better picture of what the project's flood handling

ity is, routings were made of hypothetical floods to determine what the ect can contain. The hypothetical hydrographs are obtained by applying ages to the PMF ordinates. A flood with a hydrograph having ordinates onding to 5 percent of the PMF ordinates is just controlled by the ect. Larger floods would overtop the dam.

tter will be appended to the final Dam Safety Inspection Report.

Sincerely yours,

SIDNEY KNUTSON, P.E.
Asst Chief, Engineering Division



Visit MONTANA the BIG SKY Country

BOARD OF COUNTY COMMISSIONERS
HILL COUNTY
HAVRE, MONTANA

CHAIRMAN	COMMISSIONER	COMMISSIONER
Daniel Morse	Raymond Patrick	Arthur Rambo

16 October, 1980

Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Department of the Army
Seattle District, Corps of Engineers
P. O. Box C3755
Seattle, Washington 98124

RE: Final Draft
Phase I - Inspection Report
National Dam Safety Program
Bear Paw Lake Dam
Hill County, Montana

Dear Sir:

Following study of the above report on Bearpaw Lake Dam, the Hill County Board of Commissioners concur in recommendations made by the engineering firms making the study of the dam.

In as much as there is no emergency spillway, the Board members feel it may be advisable to study the feasibility and possibility of undertaking the doubling or tripling of the present spillway capacity at the Bearpaw Lake Dam. Terrain at the dam site is such that the suggested increase in spillway capacity may be more feasible from an economic standpoint than the installation of an emergency spillway.

Sincerely yours,

Dan Morse

Daniel Morse
Chairman of the Board
HILL COUNTY COMMISSIONERS

DM/dem